

**SEDIMENT MONITORED NATURAL RECOVERY STUDIES AT THE
SANGAMO-WESTON/TWELVEMILE CREEK/LAKE HARTWELL SUPERFUND SITE**

PHASE III DATA REPORT

EXECUTIVE SUMMARY

This data report has been prepared in fulfillment of Contract No. 68-C-00-185, Task Order (TO) 0015 by Battelle under the sponsorship of the United States Environmental Protection Agency's (EPA's) National Risk Management Research Laboratory (NRMRL). The primary objective of this project was to achieve a better understanding of the natural mechanisms contributing to the recovery of polychlorinated biphenyl (PCB)-contaminated sediments at the Sangamo-Weston/Twelvemile Creek/Lake Hartwell Superfund site (hereafter referred to as the Lake Hartwell site). Specifically, this project developed and evaluated physical, chemical, and biological tools and approaches for measuring the short-term and long-term performance of monitored natural recovery (MNR) at this site. To accomplish this objective, the Lake Hartwell research addressed the following questions:

1. Are surface sediment PCB concentrations approaching the remediation goal of 1 mg/kg in the surface 10-cm?
2. Is there measurable PCB flux from the contaminated surface sediments into the water column?
3. Is there measurable PCB volatilization from the water column into the atmosphere?
4. What indicators are useful in assessing the response of aquatic biota to PCB concentrations in surficial sediments and water?
5. Are PCB fish tissue levels approaching acceptable levels that are protective of wildlife and human health?

The secondary objective of this project was to provide technical assistance to EPA Region 4 in evaluating the efficacy of the Record of Decision (ROD) remedy-of-choice for the Lake Hartwell ecosystem, namely MNR.

This data report includes the data collected under Phase III (2002 field efforts) of the Lake Hartwell program, and includes reduced, reviewed, and raw data. The hard-copy report is accompanied by an electronic CD, which contains all elements of the report, formatted in electronic folders that correspond to the report layout. Three of the appendices (Appendices F, G, and H) of the report are provided only in electronic format, to minimize unnecessary printing. This all encompassing CD is located inside the back cover.

An interpretive narrative is not provided with this report, in accordance with EPA instructions.

Data Quality Assurance/Quality Control (QA/QC).

All data in this report underwent rigorous QA/QC reviews. All data originating from Battelle's Duxbury, MA laboratories underwent QA/QC review before being released, to ensure data accuracy, and to appropriately qualify data based on QA/QC results. The data then was reduced at Battelle's Environmental Restoration (ER) department in Columbus, OH. This involved first organizing the raw data according to sample type, location, or experiment and normalizing all data to total organic carbon (TOC), lipid, or oil concentrations, as appropriate. Battelle ER's QA/QC officer reviewed this reduced data set for accuracy. The reduced data set then was tabulated or graphed to facilitate data interpretation. Battelle's QA/QC officer reviewed all tables and graphs for accuracy. It may be impossible to eliminate all errors; however, this process is designed to minimize the potential for errors in the data production and

interpretation processes, and to ensure that when data is transferred it is done so meticulously and accurately.

All QA/QC requirements conformed to the EPA-approved QAPP for this program (Battelle, 2002a).

Previous Lake Hartwell Studies (Phases I and II).

The Lake Hartwell site is located in northwestern South Carolina (Figure 1) in Pickens County. The Sangamo-Weston plant manufactured electrolytic mica and power factor capacitors from 1955 to 1978 (EPA, 1994). The plant used a variety of dielectric fluids in its manufacturing processes, including fluids containing PCBs. Waste disposal practices included land burial of off-specification capacitors and wastewater treatment sludge on the plant site and at six satellite disposal areas. PCBs were discharged with effluent directly into Town Creek, a tributary of Twelvemile Creek and Lake Hartwell. Between 1955 and 1977, the average quantity of PCBs used by Sangamo-Weston ranged from 700,000 to 2,000,000 lb/year. An estimated 3% of the quantities used by the plant were discharged into Town Creek, resulting in an estimated cumulative discharge of 400,000 lb of PCBs. An unspecified amount was buried in six off-site disposal areas. PCB use was terminated in 1977, prior to the EPA ban on its use in January 1978 (EPA, 1994).

Previous EPA/NRMRL and Battelle efforts were conducted during fiscal years 2000 (FY00) and 2001 (FY01) under Contract No. 68-C5-0075, Work Assignment 4-30, and Contract No. 68-C-00-159, Task Order 09, respectively. During FY00, ten (10) sediment cores were collected at transect locations identified by EPA Region 4 and the United States Army Corps of Engineers (USACE). Transect locations were identified as Transects T16, W7, Q, P, O, N, L, J, I, and T6. The first four transects (T16, W7, Q, and P) were located in the upgradient reaches of Lake Hartwell, and the last six (O, N, L, I, J, and T6) were located downgradient in the most northern sector of Lake Hartwell. Results of the Phase I work are described in Battelle (2002b) and Magar et al. (2002).

During the FY01 work, eight additional sediment cores were collected at three downgradient transect locations, T-O, T-L, and T-I. Three sediment cores were collected from T-O, three from T-L, and two from T-I. The cores were taken from shore to shore at each transect where possible. These additional cores were collected to better understand the historical deposition and dechlorination of PCBs from lakeshore to lakeshore, providing a three-dimensional portrait of the site.

Also during the FY01 work, 21 surface sediment samples and nine high-volume water samples were collected from the Lake Hartwell site and from the source area, near the former Sangamo-Weston Plant. The purpose of the surface sediment and high-volume water sampling was to identify the source of low-level PCBs entering the lake.

The following analyses were conducted under Phases I and II. Sediment age dating was conducted using lead-210 (^{210}Pb) and cesium-137 (^{137}Cs) techniques. Vertical PCB profiles were constructed using total PCB concentrations, to demonstrate surface sediment recovery since the late 1970s. Detailed congener analyses were performed on the 107 analyzed congeners and a polytopic vector analysis model was used to characterize the PCB source and dechlorination end-member patterns with sediment depth and time. PCB concentration data also were normalized to TOC in order to identify any apparent trends between TOC and PCB concentrations. Biphenyl concentrations also were measured in the sediments to determine if complete dechlorination to biphenyl was apparent. Because biphenyl is not a PCB, biphenyl concentrations were not included in the total PCB concentrations.

PCB concentrations in sediments collected in Town Creek, in the vicinity of the former of the Sangamo Weston plant, had total PCB concentrations that exceeded the target concentration of 1 mg/kg.

Downstream from the Sangamo-Weston plant, the total PCB concentrations decreased to a range of 23-631 ng/g at various locations in Town Creek.

Phase III Data Results.

Phase III involved using a multi-pronged approach to assessing the ongoing impact of the Lake Hartwell sediment PCBs on the benthic and aquatic environments. The Phase III experiments were implemented at Lake Hartwell in July 2002; implementation included personnel from EPA and Battelle. The tests were conducted at three locations, identified as Background, Site M/N (located between Transects M and N), and Site O (located in the vicinity of Transect O). The following experiments were conducted at Lake Hartwell. Detailed descriptions of these experiments can be found in the EPA-approved quality assurance project plan (QAPP) for this project (Battelle, 2002a):

1. PCB surface sediment and surface water samples were collected to characterize surface sediment concentrations and congener profiles for sediments in the vicinity of the numerous tests conducted at each test location.
2. Biota were collected at the site to characterize PCBs in the aquatic food chain. The following biota were collected:
 - a. Fish catches were conducted to collect, identify, and analyze native fish species.
 - b. Hester Dendy traps were deployed to collect macroinvertebrates from the benthic environment.
 - c. Uncontaminated Fat Head Minnow (FHM) fish were deployed in cages to measure their bioaccumulation of PCBs over a 28-day incubation period.
 - d. Native uncontaminated *Corbicula* clams collected from uncontaminated sediments in the region were deployed in cages, to monitor the bioaccumulation of PCBs in the clams when suspended in the water column over a 28-day incubation period.
 - e. Sport fish caught by EPA Region 4 (under a separate site visit) were analyzed for PCBs to collect congener data and for comparison with values from the state.
 - f. Phytoplankton was collected using a phytoplankton net, to characterize the phytoplankton for PCB concentrations.
3. Semipermeable membrane devices (SPMD) were deployed to simulate biota in the Lake environment. The triolein oil used in the SPMDs is selected to simulate fish lipids or other forms of natural organic carbon. The SPMDs were deployed in the Lake Hartwell environment to measure the hyperaccumulation of PCBs in the triolein oil phase. SPMD deployments included:
 - a. Aqueous phase deployments deployed for 7, 14, 28, or 56 days.
 - b. Sediment deployments deployed for 7, 14, 28, or 56 days.
 - c. Stainless steel chamber deployments deployed for 7, 14, 28, or 56 days. Chambers were either opened (vented) or closed.
4. PCB volatilization studies were conducted to measure the volatilization of PCBs of the lake surface.
5. PCB gas flux chambers were deployed to measure the gas evolution from the sediments. Gases were measured for methane (CH₄), carbon dioxide (CO₂), oxygen (O₂), and nitrogen (N₂), plus reduced sulfur gases.
6. Advective transport of the water through the sediments was evaluated with a network of piezometer wells installed adjacent to the gas flux chambers at each of the three sites. The goal was to quantify the advective flow of water between the sediment surface and the overlying water column.

This data report includes the data collected for Experiments 1 through 5, above. Data from Experiment 6 is not included herein this document. The report is formatted as follows. Following this executive

summary is a table of contents, identifying the major elements of the report. Pages are not numbered, so the *Contents* section is organized by the section tabs of the report.

The contents page is followed by a *Supporting Information* section, which provides site maps and other drawings prepared for the site. This section also includes a “Master Sample Identification” table. This table identifies all samples collected for Phase III, and their corresponding sample identification (ID) numbers. The sample ID numbers provided in this table are the same numbers used by the laboratories to identify each respective sample. Thus, the sample ID numbers may be used by the reader to trace the data for their respective origins, by going to the original data sheets provided by the laboratories. The Master Sample Identification Table also provides an outline of all samples collected for this experimental phase. In addition to the Master Sample Identification table, a “Gas Analyses Identification Table” matrix is provided for the non-PCB gas analyses that were conducted.

The *Results* section is next, and provides reduced tabulated and graphed data. Tables and graphs are similar to those already seen by many members of the Lake Hartwell research group. Corresponding tables and graphs are presented together, so the reader can compare the results of both formats. This section provides the following reduced data sets:

- PCB data results provide concentrations of total PCBs, generally graphed in a bar-chart format. PCB concentrations in the various media are compared among the different locations (Background, T-M/N, or T-O) or at a single location over time (7, 14, 28, and/or 56 days), or both. Replicate data points were averaged when three or more data points existed. Error bars on the graphs show the standard deviations for these average values. Graphed data that do not show error bars indicate that either less than three samples were collected, or the error bars are too narrow to be seen within the scale of the drawings. The reader is referred to the tabulated data, which also shows averages, standard deviations, and numbers of samples used for each analysis.
- PCB congener data presents and compares the congener distributions for the various media analyzed, including sediments, water, biota, and SPMDs. The congener data relied on one representative sample from each matrix, and did not use average values for each congener. However, the generally low standard deviations of the total PCB concentrations within each medium suggested that values were reproducible and that the use of a single representative sample was an acceptable approach for the congener graphs.
- PCB Aroclor analysis results provide comparisons of total-PCB concentrations determined using Battelle’s congener analyses and PCB Aroclor method using EPA Method *SW846 8082 PCB Aroclor*. Tables show all data points, and graphs show averages \pm standard deviations for each sampled matrix, including fish, sediment, water, and SPMD.
- PCB volatilization tables and graphs show the volatilization flux and congener distributions for PCB sediment, aqueous-phase, and volatilized samples.
- Gas evolution measurements include total gas volumes collected over time, and CH₄/CO₂/N₂/O₂ measurements. Reduced sulfur measurements also are included when available. For several samples, insufficient volume was available to conduct the reduced sulfur measurements, as noted in the tables.

Phase III Appendices.

The following appendices are included in this document:

1. Appendices A, B, and C include reduced and normalized PCB data for the biota, sediments, SPMDs, volatilization samples, and water, for the Background, T-M/N, and T-O sites, respectively. (PCB concentrations for polyurethane foam [PUF] volatilization samples and

aqueous samples are not normalized, of course.) In addition to organizing the data by location, the data in these appendices also are organized by experimental matrix and/or collection time.

2. Appendix D includes normalized PCB data for the upgradient locations in Town Creek.
3. Appendix E includes all analyses associated with the gas samples.
4. Appendix F includes IUPAC PCB nomenclature, to identify specific PCB congeners using the IUPAC numerical format used in the tables and graphs.
5. Appendix G provides field notes in an electronic format only in the attached CD. Field notes were scanned into a .PDF file and can be printed by the reader as needed.
6. Appendix H includes photographs, also provided only in electronic format, in the attached CD.
7. Appendix I includes the raw data files, also only in electronic format in the attached CD. The raw data files are those received from the laboratories and have undergone no processing or data reduction. The raw data allows the reader to access the original data as they were received by the laboratory, if necessary.

References

Battelle. 2002a. *Final Quality Assurance Project Plan: Sediment Monitored Natural Recovery Studies at the Sangamo-Weston/Twelvemile Creek/Lake Hartwell Superfund Site*. EPA QAPP No. 163-Q5-0.

Battelle. 2002b. *Natural Recovery of Persistent Organics in Contaminated Sediments at the Sangamo-Weston/Twelvemile Creek/Lake Hartwell Superfund Site*. Prepared for USEPA Natl. Risk Mgmt Res. Lab. Cincinnati, OH. Contract No. 68-C-00-159. November 20.

Magar, V.S., J. Ickes, J.E. Abbott, R.C. Brenner, G. S. Durell, C. Peven-McCarthy, G.W. Johnson, E.A. Crecelius, and L.S. Bingler. 2002. "Natural Recovery of PCB-Contaminated Sediments at the Sangamo-Weston/Lake Hartwell Superfund Site." In R.E. Hinchey, A. Porta, and M. Pellei (Eds.), *Remediation and Beneficial Reuse of Contaminated Sediments*, Vol. 1(3), pp. 413-418. Battelle Press, Columbus, OH.

United States Environmental Protection Agency. 1994. *Superfund Record of Decision: Sangamo-Weston/Twelvemile Creek/Lake Hartwell Site, Pickens, GA: Operable Unit 2*. EPA/ROD/R04-94/178.

CONTENTS

EXECUTIVE SUMMARY

CONTENTS

SUPPORTING INFORMATION

Site Maps and Drawings
Master Sample Identification Table
Gas Analyses Identification Table

RESULTS

PCB Data Results

- Tables
- Figures

PCB Congener Data

- Figures

Total PCB Comparisons: Aroclor vs. Congener

- Table
- Figures

PCB Volatilization

- Tables
- Figures

Gas Evolution

- Tables
- Figures

APPENDIX A: Normalized PCB Data (Background Site)

Appendix A-1: Normalized PCB Data (Biota)
Appendix A-2: Normalized PCB Data (Sediment)
Appendix A-3: Normalized PCB Data (SPMDs)
Appendix A-4: Normalized PCB Data (Volatilization)
Appendix A-5: Normalized PCB Data (Water)

APPENDIX B: Normalized PCB Data (Transect M/N)

Appendix B-1: Normalized PCB Data (Biota)
Appendix B-2: Normalized PCB Data (Sediment)
Appendix B-3: Normalized PCB Data (SPMDs)
Appendix B-4: Normalized PCB Data (Volatilization)
Appendix B-5: Normalized PCB Data (Water)

APPENDIX C: Normalized PCB Data (Transect O)

Appendix C-1: Normalized PCB Data (Biota)
Appendix C-2: Normalized PCB Data (Sediment)
Appendix C-3: Normalized PCB Data (SPMDs)
Appendix C-4: Normalized PCB Data (Volatilization)
Appendix C-5: Normalized PCB Data (Water)

APPENDIX D: Normalized PCB Data (Upgradient Locations)

Appendix D-1: Normalized PCB Data (Biota)

Appendix D-2: Normalized PCB Data (Sediment)

Appendix D-3: Normalized PCB Data (SPMDs)

Appendix D-4: Normalized PCB Data (Volatilization)

Appendix D-5: Normalized PCB Data (Water)

APPENDIX E: Gas Sample Data

APPENDIX F: IUPAC PCB Nomenclature and Numerical Identification

APPENDIX G: Field Notes (See CD)

APPENDIX H: Photographs (See CD)

APPENDIX I: Raw Data (See CD)